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of seismologic phenomena, that a new volume of five hundred pages by M. Montessus de Ballore, entitled *Les tremblements de terre*, has been recently published at Paris. In the preface M. de Lapparent directs attention to the great statistical value of the author's catalogue of earthquakes, and to the fact that he has brought seismology into its relations with geologic structure.

J. C. BRANNER.

The Linear Force of Growing Crystals, and an Interesting Pseudo-Solid. By G. F. BECKER AND A. L. DAY. Proceedings of the Washington Academy of Sciences, Vol. VII (1905), pp. 251-300.

About six months ago a modest paper, filling only five octavo pages, was published by George F. Becker and Arthur L. Day upon the "The Linear Force of Growing Crystals."¹ The writer has looked in vain for expressions of appreciation of this important piece of work.

Evidences of the linear force of growing crystals have long been familiar to geologists, but while the process of growth seemed clear enough from field observations, the demonstration of it and its quantitative determination have hitherto been altogether lacking, while the writer's efforts to interest chemists and physicists competent to deal with the problem have failed of success for twenty years. Discussions of the origin of secondary veins usually proceed on the theory of cavities, or of the replacement of one mineral by another. So far as we now recall, not one of the many writers on this much-discussed subject has ventured the suggestion that the growing force of crystals may have thrust apart the rock walls, and thus made room for the veins in the very process of formation. A few geologists have suggested that some such force operated in the formation of veins, but these are so few, and their suggestions have been made with such apparent hesitation, that little or no attention has been paid to them by the more voluminous writers upon ore deposits.

In 1882 Chamberlin recognized the displacing force of growing crystals of sphalerite, galenite, and pyrite in the ore deposits of southwestern Wisconsin, as indicated by the following quotations from Vol. IV of *Geology of Wisconsin*:

In most instances it is perfectly clear, from the nature of the ore filling, that the separation of the beds took place before the implanting of the ores,

¹ *Proceedings of the Washington Academy of Sciences*, Vol. VII (July, 1905), pp. 283-88.

and was not due to any intrusive or crystalline force inherent in the deposit itself. Some, however, instead of being simple sheets between well-defined layers of rock, split and reunite, forming between and about cracked and riven layers of rock, leaving it less clear that all the mechanical action preceded the deposition of the ores. In other cases "dice mineral" and blende impregnate soft beds of rock in sheetlike belts, in which instances it is quite evident that the metaliferous substances displaced the yielding rock in the process of their growth. (P. 468.)

Upon close inspection the soft clayey rock will be found to be thickly inset with scattered crystals of black blende, giving to the fractured rock a beautiful speckled appearance. Looking still closer, it will be seen that the laminae of the rock curve around the particles of blende, showing that they were displaced by the growth of the blende crystals. (See Fig. 39.) We have in this and the next instance just as clear cases of the forming mineral making room for itself by its own concretionary force, as in some preceding cases it is evident that the receptacle was first formed and the ore subsequently implanted. (P. 474.)

Two other cases are cited, pp. 474, 475, and p. 464.

The first edition of Branner and Newsom's syllabus of economic geology, published in 1895, referred (p. 28; p. 36 of the second edition, 1900) to the enlargement of veins by accretion, under the following heads: "Illustration of needle-ice and crystallization in the soil. The size, form, and structural relations of some geodes shown to be due to enlargement. Evidences of mechanical force of the process. Possible relations to vein enlargement; to brecciation."

That same year, 1895, the fourth edition of Dana's *Manual of Geology* appeared, in which Professor Dana briefly mentions (p. 138) "displacement by intrusion of crystalline material," and cites Worthen upon the splitting and enlargement of crinoids. The paper of Worthen has not been located by the writer. In 1899 Professor Shaler published a paper upon the formation of dikes and veins,¹ in which he uses geodes as illustrations of vein-forming, and remarks (p. 262) that "the pressure of the growing vein . . . is likely to be even more effective in the group of tabulate deposits in forcing the walls asunder." This is the only instance, with which the writer is acquainted, in which the relation of geode formation to veins has been formally discussed.

In the twentieth annual report of the United States Geological Survey, Part II, published in 1900, Professor I. C. Russell says in regard to the filling of certain brecciated veins (p. 207): "I venture the suggestion that these minerals (quartz and calcite), in crystallizing, have exerted a

¹ *Bulletin of the Geological Society of America*, Vol. X, pp. 253-62.

force analogous to the expansion of water on freezing, which has crowded the rock fragments asunder."

In 1900 also an article by R. A. Daly appeared in the *Journal of Geology* (Vol. VIII, pp. 135-50), in which the author shows the evidence of mechanical force exerted in the formation of calcareous concretions.

Messrs. Becker and Day have now not only demonstrated the mechanical force of growing crystals, but they have been able to measure that force in some instances. The bearing of this work upon the formation of veins is recognized by the authors, for they conclude that

it thus becomes possible that . . . great veins have actually been widened to an important extent, perhaps as much as 100 per cent., or even more, by pressure due to this cause. . . . Again, in a vein where auriferous quartz is being deposited, the growth of crystals may readily extend the space in which successive crops of crystals might grow, so that in certain cases . . . the deposition of ore might continue almost indefinitely.

The investigation is to be continued, and we shall be greatly disappointed if it does not prove to be one of the most important modern contributions to the theory of vein deposits.

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